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"It Takes Two": The Interaction Between Parenting and Child Temperament on Parents' Stress Physiology

ABSTRACT: *The biological basis of parenting has received recent attention given the profound effects of parenting on both child and parent health outcomes. This study examined the moderating role of child temperamental effortful control on the association between observed parental hostility and parents' cortisol awakening response (CAR), a critical index of stress system functioning. Participants included 149 parents and their preschool-aged children. Parents obtained salivary cortisol samples at waking, and 30 and 45 min post-waking across two consecutive days. Parental hostility was assessed during an observational parent–child interaction task, and child effortful control was assessed using parent report. Parental hostility was associated with parents' lower cortisol levels at 30 and 45 min post-waking and lower CAR. Moreover, results demonstrated an interaction between parenting and child temperament on parent CAR. The findings highlight the need to examine the interplay between parenting and child temperament on parents' stress physiology.* © 2015 Wiley Periodicals, Inc. *Dev Psychobiol*

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INTRODUCTION

Cross-sectional and longitudinal studies have consistently demonstrated the profound impact of parenting on children's brain, behavioral, cognitive, emotional, and social development (Belsky & de Haan, 2011). Likewise, research has demonstrated that the parent–child relationship involves bidirectional processes that impact the parent's own physical health and well-being (Barrett & Fleming, 2011; Deater-Deckard, 2004). Indeed, the daily chronic stress from parenting is a stronger predictor of parent, child, and family functioning than family exposure to acute major life stressors (Crnic & Greenberg, 1990). Moreover, chronic exposure to parenting stress contributes to increases in negative parenting behaviors and decreases in parental well-being (Deater-Deckard, 2004).

Parenting and Neurobiology

In order to delineate the complex pathways from parenting to adverse parent and child health outcomes, emerging research is beginning to investigate how parenting behaviors relate to parents' neurobiology and physiological responses. Research has documented associations between parenting and parents' autonomic reactivity (Lorber & O'Leary, 2005), brain function (Rilling, 2013), and hormone levels (Feldman, Weller, Zagoory-Sharon, & Lavine, 2007). In addition, parenting has been linked to parents' hypothalamic-pituitary-adrenal (HPA) axis functioning, one of the body's major

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stress-response systems. Specifically, maternal sensitivity has been linked to mothers' lower diurnal cortisol, decreased cortisol reactivity, and greater adrenocorticol attunement with their child (Gonzalez, Jenkins, Steiner, & Fleming, 2012; Sethre-Hofstad, Stansbury, & Rice, 2002; Thompson & Trevathan, 2008). In contrast, controlling and inconsistent parenting practices have been linked to mothers' increased cortisol reactivity (Sturge-Apple, Davies, Cicchetti, & Cummings, 2009).

Parenting, Child Behavior, and Parents' HPA Axis Functioning

Links between parenting and parents' HPA axis functioning are particularly important given that the HPA axis plays a critical role in physical and mental health and vulnerability to life stress (Chida & Steptoe, 2009), all of which likely impact parenting and the quality of the parent–child relationship. Moreover, parent and child behaviors do not occur in isolation, but involve bidirectional and transactional interactions; thus, it is likely that parent and child factors jointly influence parents' stress physiology and regulatory capacities. This is consistent with the parent–child relationship and daily hassles theories of parenting stress, which propose that reciprocal and transactional processes between parent and child emerge in day-to-day experiences and influence both parent and child behaviors and functioning (Deater-Deckard, 2004). While research has consistently demonstrated that both parent and child factors are linked to children's stress physiology (Gunnar & Quevedo, 2007), only two previous studies have examined associations between parenting, child behavior, and parents' own stress physiology (Kiel & Buss, 2013; Martorell & Bugental, 2006). Martorell and Bugental (2006) found that in a sample of 60 mothers in family support programs, children's temperament moderated the association between maternal perceived powerlessness and mothers' cortisol reactivity. Specifically, mothers of children with difficult temperament and who had low perceived power had higher cortisol reactivity. Alternatively, Kiel and Buss (2013) examined whether maternal cortisol reactivity moderated the association between child temperament and parenting behavior in a sample of 92 mother-child dyads. They found that mothers of highly inhibited children and who had high cortisol reactivity were observed to be more intrusive. These studies demonstrate that parenting and child behaviors are linked to parents' cortisol reactivity. However, cortisol reactivity is only one aspect of parents' stress physiology, and no previous study has examined the moderating role of child temperament on associations between observed parenting and parents' diurnal cortisol levels.

Parents' Cortisol Awakening Response (CAR)

One critical aspect of the diurnal cortisol rhythm is the cortisol awakening response (CAR) or the natural rise in cortisol 30–45 min after waking. The CAR is a reliable index of adrenocortical activity in adults (Pruessner et al., 1997) and evidences both genetic and environmental components (Kupper et al., 2005; Wüst, Federenko, Hellhammer, & Kirschbaum, 2000a). Importantly, abnormalities in the CAR have been related to a number of adverse health outcomes, both physical and psychological, including chronic stress, fatigue, depression, and other stress-related disorders (Chida & Steptoe, 2009), and may reflect a physiological response in anticipation of the day's demands (Fries, Dettenborn, & Kirschbaum, 2009). Moreover, the CAR has been found to predict the development of depressive and anxiety disorders (Adam et al., 2010, 2014). Given the far-reaching impact of the CAR on parents' physical and psychological health, as well as the established influence of parent and child factors on parents' stress physiology, it is critical to examine the associations between parenting, child temperament, and parents' CAR.

While no study has examined parents' CAR in relation to these factors, a few studies have examined parents' diurnal cortisol levels in parents of children with disabilities (e.g., cerebral palsy, autism) (e.g., Bella, Garcia, & Spadari-Bratfisch, 2011; Seltzer et al., 2010). These studies demonstrate that parents of children with disabilities, who experience greater chronic stress from caregiving, display lower levels of diurnal cortisol, including lower morning cortisol levels, suggesting that the additional chronic stress of caring for a child with a disability disrupts parents' HPA axis functioning, leading to decreased cortisol secretion. These findings are consistent with the literature indicating that higher levels of chronic stress are related to blunted cortisol activity (Fries, Hesse, Hellhammer, & Hellhammer, 2005; Heim, Ehlert, & Hellhammer, 2000) and highlight the important role child factors play on parent's diurnal cortisol rhythm.

Current Study

The current study examined whether the association between parental hostility and parents' stress physiology, specifically the CAR, is moderated by child temperamental effortful control. Temperament refers to patterns of behavioral and emotional reactivity and regulatory processes that are relatively stable and are rooted in part in early developing biological systems (Rothbart, 2007; Shiner et al., 2012). Effortful control, one critical dimension of child temperament, reflects the child's self-regulatory abilities, accounting for the

child's ability to suppress dominant behaviors and maintain subdominant behaviors (Kochanska, Murray, & Harlan, 2000). Effortful control was chosen as a temperamental construct to reflect children's difficulties with inhibitory impulses which may be particularly difficult for parents to manage, as lower levels of effortful control are associated with children's increased internalizing and externalizing behavior problems (Eisenberg et al., 2001). Parents who exhibit increased parental hostility may have greater difficulty interacting with a child with lower levels of effortful control, and this combination of difficult child temperament and negative parenting may impact parents' stress physiology. Establishing the impact of the parent-child dyad on parents' CAR has significant implications for parents' physical and mental health as well as child outcomes and may help identify families at risk.

We examined this question in a sample of 149 parents and their preschool-aged children. Observed parental hostility was assessed during laboratory-based parent–child interaction tasks and children's temperamental effortful control was assessed through parent report. Parents' HPA axis functioning was measured across two days through the parents' CAR, which included salivary cortisol samplings at waking and 30 and 45 min post-waking. The CAR was quantified using two indices: area under the curve with respect to ground (AUC_g) and area under the curve with respect to increase (AUC_i). These two indices have been shown to be related but also to capture distinct aspects of the CAR (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003). AUC_g captures the *total volume* of cortisol secreted across the waking period, whereas AUC_i captures the *total increase* in cortisol across the waking period (Pruessner et al., 2003). We also examined cortisol levels at each specific time point across the post-waking period in order to identify how parenting may relate to specific features of the CAR.

We first examined associations between observed parental hostility and child effortful control and parents' CAR. While the broader literature on the CAR has been generally mixed, with both higher and lower CAR linked to chronic stress and negative health outcomes (Bhagwagar, Hafizi, & Cowen, 2005; Fries et al., 2005, 2009; Heim et al., 2000), we held no a priori expectations regarding whether increased parental hostility or lower levels of child effortful control would be associated with increased or decreased CAR. Next, we examined the moderating effect of child effortful control on the associations between parental hostility and parents' cortisol activity. Given the paucity of research examining the moderating role of child temperament on associations between parenting and parents' CAR, we tentatively hypothesized that associations between higher levels of observed parental hostility and parents' cortisol responses would be stronger in parents of children with lower levels of effortful control.

Given the cross-sectional nature of this study, we recognize that directionality cannot be tested, and parenting, child temperament and parent stress physiology likely have multiple bidirectional and transactional relations. Our hypothesized model tests the moderating role of child effortful control on the association between parenting and parents' CAR. However, consistent with Kiel and Buss (2013), it is also possible that the interaction between child temperament and parents' stress physiology may relate to individual differences in parenting behavior. Thus, we also examined the moderating role of parents' CAR on the association between child effortful control and parental hostility in order to test the specificity of our proposed model.

Finally, we are testing our hypotheses in a sample that over-selected parents with a lifetime history of depression: 49.7% of parents had a lifetime history of depression. Previous research has observed associations between depression and abnormalities in the CAR (Vreeburg et al., 2009), and depressed parents have been found to evidence more hostile and less warm parenting behaviors (Barrett & Fleming, 2011; Lovejoy, Graczyk, O'Hare, & Neuman, 2000). Moreover, parental depression has been linked to early child temperament (Olino, Klein, Dyson, Rose, & Durbin, 2010). Given these established links between parental depression and the parent and child factors examined in the study, we tested whether our findings remain after controlling for parental lifetime depression history or excluding parents with current depression to rule out that our observed interactive effects were due to parental depression.

METHOD

Participants

Participants consisted of 175 primary caregivers and their biological preschool-aged children (Dougherty, Tolep, Smith, & Rose, 2013). Participants were recruited from the Washington, DC metropolitan area using print advertisements distributed to local schools, daycares and health care providers (73.1%), and a commercial mailing list (26.9%). The study targeted a subsample of parents with a history of depression. Families were included if they had a child between 3 and 5 years of age, who had no significant medical condition or developmental disabilities, with no parental history of bipolar or psychotic disorder, and who

lived with at least one English-speaking biological parent. This study was approved by the University of Maryland's human subjects review board, and informed consent was obtained from all parents.

Of the 175 families recruited for the larger study, 156 primary caregivers (145 mothers, 11 fathers) provided home cortisol samples. Of these 156 parents, six were excluded because of extreme cortisol values (>3 *SD* above the mean; Gunnar & White, 2001), and one parent was excluded based on noncompliance to the instructed sampling times (see below for details on sampling compliance). Thus, the final sample consisted of 149 parents (138 mothers, 11 fathers) with valid cortisol samples. There were no significant differences between participants included in analyses ($n = 149$) and those excluded ($n = 7$) on any study variable.

Parent's mean age was 35.0 years ($SD = 6.56$; mothers: $M = 34.5$, $SD = 6.2$, fathers: $M = 41.6$, $SD = 7.72$). Children's mean age was 45 months ($SD = 9.05$). Participating families identified themselves as White/European–American ($n = 70$; 47.9%), Black/African–American ($n = 51$; 34.9%), Asian ($n = 2$; 1.4%), multiracial ($n = 10$; 6.8%), or other race ($n = 13$; 8.9%); 26 (17.8%) families were of Hispanic/Latino descent. More than half of parents ($n = 90$; 60.4%) reported having at least a 4 year college degree. Participating families reported a range of family incomes: less than $20,000 (6.9%), $20,000–$40,000 (10.4%), $40,001–$70,000 (19.4%), $70,001–$100,000 (29.2%), and greater than $100,000 (34.0%). The majority of participating parents ($n = 110$; 74.3%) were married or cohabitating. See Table 1 for demographic characteristics of the sample.

Measures

Observed Parental Hostility. During the first laboratory visit, parents and children participated in an observational parent–child interaction task, based on a modified version of the Teaching Tasks battery (Egeland et al., 1995). The battery included five standardized tasks including book reading, a guessing game, a maze, a story sequencing task, and a puzzle game. Each task was videotaped and coded for parental hostility. Parental hostility was defined as the parent's expression of anger, frustration, and criticism toward the child. For each task, parental hostility (Book Reading: $M = 1.11$, $SD = .35$, Range 1–3; Guessing Game: $M = 1.11$, $SD = .39$, Range 1–4; Maze: $M = 1.17$, $SD = .46$, Range 1–4; Story: $M = 1.19$, $SD = .47$, Range 1–4; Tangoes Puzzles: $M = 1.16$, $SD = .44$, Range 1–3) was rated on a five-point scale from one (''no signs of anger, annoyance, frustration, or rejection'') to five (''frequent/consistent expressions of hostility or rejection toward the child''), and scores were then averaged across the five tasks for a composite measure of parental hostility ($M = 1.15$, $SD = .29$, Range 1–2.6). The parental hostility scale demonstrated adequate internal consistency ($\alpha = .76$), and the intraclass correlation coefficient (ICC) for the inter-rater reliability based on video-recordings of 38 dyads was good (ICC = .89).

Parental Psychopathology. Parents were interviewed using the Structured Clinical Interview for DSM-IV, Non-Patient version (SCID-NP; First, Spitzer, Gibbon, & Williams, 1996). Interviews were conducted by telephone, which yields similar results as face-to-face interviews (Rohde, Lewinsohn, & Seeley, 1997), by a master's level rater with extensive training in the SCID. SCIDS were obtained by 147 parents (98.7%; 138 mothers, nine fathers). A history of major depressive disorder (MDD) and/or dysthymic disorder (DD) were collapsed into a single category reflecting lifetime depressive disorder. Of parents who gave cortisol samples, 73 parents (49.7%; 69 mothers, four fathers) had a lifetime depressive disorder, and 12 parents (8.1%; 11 mothers, one father) had a current depressive disorder (past month) at the time of the assessment. Based on audiotapes of 16 SCID interviews, the κ for inter-rater reliability was 1.00 for a lifetime depressive disorder.

Child Effortful Control. One hundred and forty-seven parents completed the Child Behavior Questionnaire-Short Form (CBQ-SF; Putnam & Rothbart, 2006), a 94-item parent-report measure for assessing temperament in children ages 3–7 years. The effortful control scale ($M = .04$, $SD = 3.11$, $\alpha = .78$) was created as a composite of five standardized (z-score) subscales including a total of 32 items (Low Intensity Pleasure: eight items, Smiling/Laughter: six items, Inhibitory Control: six items, Perceptual Sensitivity: six items, and Attentional Focusing: six items). Parents rated each item on a scale from one to seven where one indicates ''extremely untrue of your child'' and seven indicates ''extremely true of your child.'' Items characteristic of the scale include ''my child will move from one task to another without completing any of them'' (reverse scored) and ''my child can easily stop an activity when s/he is told no.''

Parent CAR Assessment. Parents were instructed to obtain a total of six salivary cortisol samples across two consecutive days. For each day, they were instructed to take samples immediately after waking, and 30 and 45 min post-waking. Sampling times were selected to capture the cortisol awakening response

Table 1. Participant Characteristics and Salivary Cortisol Indicators ($N = 149$)

	% (*N*)	*M (SD)*	Min	Max
Parent sex (female)	92.6 (138)			
Parent age (years)		35.0 (6.57)	21.00	57.00
Child age (months)		45.00 (9.04)	36.00	60.00
Parent marital status				
Married or cohabitating	74.3 (110)			
Widowed	.7 (1)			
Divorced, separated	8.9 (13)			
Never married	16.2 (24)			
Parent education				
Some high school	.7 (1)			
High school graduate (or GED)	4.0 (6)			
Some college (or 2 year degree)	34.9 (52)			
4 year college degree or more	60.5 (90)			
Child race/ethnicity				
White	47.9 (70)			
Black/African-American	34.9 (51)			
Asian	1.4 (2)			
Multi-racial	6.8 (10)			
Other	8.9 (13)			
Hispanic	17.8 (26)			
Income				
<$20,000	6.9 (10)			
$20,001–$40,000	10.4 (15)			
$40,001–$70,000	19.4 (28)			
$70,001–$100,000	29.2 (42)			
>$100,000	34 (49)			
Medication-Free	66.4 (99)			
Parental lifetime depressive disorder	49.7 (73)			
Parental observed hostility		1.17 (.33)	1.00	2.60
Child effortful control		.04 (3.11)	−7.79	6.38
Parental salivary cortisol indicators				
Time of waking (h), Day 1		6:56 (1:04)	3:00	10:30
Time of waking (h), Day 2		6:54 (1:07)	3:45	11:00
Cortisol waking values (nmol/L), Day 1		9.47 (5.74)	.44	31.52
Cortisol waking values (nmol/L), Day 2		9.36 (4.52)	.25	23.38
Cortisol waking + 30 min values (nmol/L), Day 1		12.11 (6.67)	.53	34.16
Cortisol waking + 30 min values (nmol/L), Day 2		12.12 (5.35)	.56	29.87
Cortisol waking + 45 min values (nmol/L), Day 1		10.40 (5.50)	.52	33.31
Cortisol waking + 45 min values (nmol/L), Day 2		10.04 (4.72)	.77	25.06
AUC_g (nmol/L), Day 1		50.36 (25.30)	2.24	141.17
AUC_g (nmol/L), Day 2		49.86 (19.57)	2.60	111.11
AUC_i (nmol/L), Day 1		7.11 (17.92)	−42.27	52.41
AUC_i (nmol/L), Day 2		7.65 (14.19)	−20.43	58.72

One family did not report on parent marital status, three did not report on race/ethnicity, and five did not report on income. Categorical variables are presented as frequency and percentage; continuous variables are presented as mean and standard deviation. The child effortful control scale was created as a sum of five standardized (z-score) subscales. Cortisol values reflect raw values and are presented in nmol/L. Area under the curve (AUC) was measured with respect to ground (AUC_g) and increase (AUC_i).

(CAR), or the rise in cortisol after awakening. Samples were collected on two days in order to assess reliably the CAR (Hellhammer et al., 2007), and on weekdays only as the type of day has been associated with cortisol levels (Kunz-Ebrecht, Kirschbaum, Marmot, & Steptoe, 2004). Of the 929 samples collected across the morning, 51 (5.49%) were excluded due to extreme cortisol values (i.e., >3 standard deviations above the mean; Gunnar & White, 2001), leaving 878 cortisol samples from 150 participants.

For the collection of cortisol, parents were instructed to chew on a cotton dental roll. After the cotton roll was saturated, parents were instructed to use a needleless syringe to expel the saliva into a vial. Parents were instructed to label and refrigerate the samples until returning to the laboratory for a second visit. At that time, the samples were then stored at −20°C until assayed. Samples were assayed in duplicate at the University of Trier, Germany. Samples were assayed with a time-resolved immunoassay with fluorometric end point detection (DELFIA). Inter- and intra-assay coefficients of variation ranged between 7.1%–9.0% and 4.0%–6.7%, respectively.

Cortisol variables used in analyses included cortisol values at waking, 30 min post-waking, 45 min post-waking, and the CAR. The CAR was captured in two ways: the area under the curve with respect to ground (AUC_g; total cortisol secreted across morning samples) and with respect to increase (AUC_i: the total change in morning cortisol levels) for the waking, 30, and 45 min post-waking samples (Pruessner et al., 2003). Cortisol variable distributions were inspected for normality. All cortisol values and the AUC variables were normally distributed and untransformed values were used in analyses.

Parental Compliance to Cortisol Sampling. Parents completed a daily diary measure to record their time of waking and sampling times. Previous studies have indicated that participant compliance to sampling procedures is necessary for accurate measurement of the CAR (Broderick, Arnold, Kudielka, & Kirschbaum, 2004). To define compliance at the sample level, a time window criterion was applied to samples. Based on previous work (e.g., Broderick et al., 2004; Smith & Dougherty, 2014), a time window of ± 10 min has been selected for samples that compose the CAR (waking, 30, and 45 min post-waking samples), as cortisol levels change rapidly during the morning (Clow, Thorn, Evans, & Hucklebridge, 2004). Samples collected within these respective time windows were considered to be collected in compliance with the specified sampling time. Based on this assessment of compliance, 157 (17.88%) of 878 samples were excluded from analysis, leaving a final total of 721 valid cortisol samples from 149 participants.

Parents' Medication Use. As evidence suggests that HPA axis activity is sensitive to prescription or over-the-counter medication use (Granger, Hibel, Fortunato, & Kapelewski, 2009), we examined parents' medication use as a covariate. Of the 149 participants, 50 parents were taking medications at the time of the assessment (e.g., psychotropic, pain, and/or general health medications such as thyroid, high blood pressure medications, and oral contraceptives). We also conducted supplementary analyses to replicate findings in parents who were medication-free at the time of the assessment ($n = 99$).

Data Analysis Plan

The dependent variables were parents' cortisol levels at each sampling time (waking, 30, 45 min post-waking) and AUC_g and AUC_i. The independent variables were parental hostility, child effortful control, and a parental hostility x child effortful control interaction term. To examine main and interactive effects of parental hostility and child effortful control on parent's cortisol, we conducted repeated-measures analyses using generalized estimating equations (GEE). GEE is a statistical method that accounts for within-person correlations over time (Liang & Zeger, 1986). Since cortisol samples were taken across days, GEE accounts for the within-person correlation between the repeated cortisol measurements. For each GEE model, parental hostility and child temperament and their cross-product were entered as independent variables, and cortisol values at each time point (waking, 30, and 45 min post-waking), AUC_g, and AUC_i were included as dependent variables in separate models. Significant interactions were probed using simple slopes analyses (± 1 SD), as described by Aiken and West (1991). As a measure of effect size, we calculated pseudo-r^2 using the Wald X^2 estimates. The Wald estimate was divided by the total of the Wald estimates for each of the independent variables in the model.

Significant interactions were also examined using Hayes and Matthes' (2009) guidelines to test for regions of significance according to the Johnson-Neyman technique (Johson & Fay, 1950). This method uses the asymptotic variances, covariances, and other regression parameters to determine regions of the moderator where the effect of the focal predictor variable on the outcome is significant and non-significant. In this study, parental hostility was the focal predictor variable and the moderator was child effortful control.

RESULTS

Descriptive Data

Table 1 shows descriptive statistics for the sample's demographics, potential covariates, and cortisol levels in nanomoles per liter (nmol/L). Pearson product-moment correlations were conducted to assess the stability of cortisol levels across sampling days. The correlations between day 1 and day 2 waking, 30

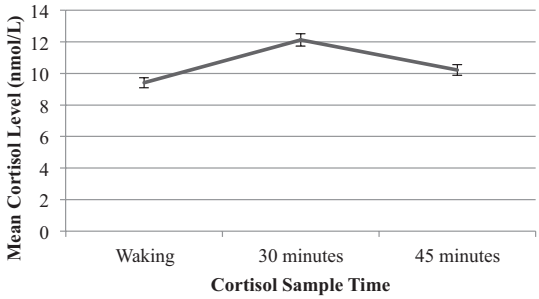

FIGURE 1 Mean parent cortisol level (nmol/L) as a function of sampling time. The graph shows mean cortisol values across days for each of the four sampling times: waking, 30 min post-waking, and 45 min post-waking. Bars reflect standard errors of measurement.

minutes post-waking, and 45 minutes post-waking cortisol were $r = .47$, .55, and .59, respectively (p's $< .05$). The correlations between day 1 and day 2 AUC_g and AUC_i were $r = .69$ and .34, respectively ($p < .01$). Figure 1 shows that on average across days, cortisol values (nmol/L) followed a typical morning pattern: they were high upon awakening ($M = 9.41$, $SD = 5.17$), increased and peaked 30 minutes post-waking ($M = 12.12$, $SD = 6.05$), and declined slightly 45 minutes post-waking ($M = 10.22$, $SD = 5.13$).

Next, we examined associations between cortisol and several potential covariates, including time of waking, parental education, parental marital status, family income, race/ethnicity, parent gender, and medication use. Time of waking was negatively associated with cortisol at 45 minutes post-waking ($B = -0.02$, $SE = .01$, $p = .03$), AUC_g ($B = -0.07$, $SE = 0.03$, $p = .02$) and AUC_i ($B = -0.05$, $SE = 0.02$, $p = .02$). Parental education (0 = no college degree, 1 = at least college degree) was positively associated with cortisol at 30 minutes post-waking ($B = 2.17$, $SE = 0.94$, $p = .02$), 45 minutes post-waking ($B = 1.77$, $SE = 0.85$, $p = .04$), and AUC_g ($B = 8.38$, $SE = 3.91$, $p = .03$). Parent gender, marital status, family income, race/ethnicity, and medication use were not significantly associated with parents' cortisol levels. Thus, time of waking and parental education were included as covariates in subsequent analyses. Child effortful control was not significantly associated with observed parental hostility ($r = -.05$, $p = .58$).

Parental Hostility, Child Effortful Control, and Parent CAR

The main effects of parental hostility and child effortful control on parents' CAR are shown in Table 2. Higher levels of observed parental hostility were significantly associated with parents' lower cortisol levels at 30 minutes and 45 minutes post-waking, as well as for lower AUC_g. Parent-reported child effortful control was not significantly associated with parents' morning cortisol levels.

Next, we examined the moderating role of child effortful control on the associations between parental hostility and parent salivary cortisol. For each GEE model, parental hostility and child temperament and their cross-product were entered as independent variables, and cortisol values at each time point (waking, 30, and 45 minutes post-waking), AUC_g, and AUC_i were included as dependent variables in separate models. There was no significant interaction between parental hostility and child effortful control on parent AUC_g ($B = 3.49$, $SE = 2.11$, $p = .10$). However, as seen in Table 3, there was a significant interaction between child effortful control and parental hostility on parents' AUC_i ($B = 3.49$, $SE = 1.00$, $p < .001$)[1]. Figure 2 shows that for parents of children with lower levels of effortful control, parental hostility was negatively associated with parents' AUC_i ($B = -6.58$, $SE = 2.01$, $p < .01$). In contrast, for parents of children with higher levels of effortful control, parental hostility was not significantly associated with parent AUC_i ($B = 0.39$, $SE = 1.22$, $p = .75$). To examine the degree of child effortful control at which parental hostility was significantly associated with parents' AUC_i, Hayes and Matthes' (2009) guidelines were used to test for regions of significance according to the Johnson–Neyman method (Johnson & Fay, 1950). The association between parental hostility and parents' AUC_i is significant at levels of child effortful control less than .16 (standardized z-score).

We also examined the interaction effects between parenting and child effortful control on cortisol levels at each sampling time. There was a significant interaction between parental hostility and child effortful control on parents' cortisol at 45 min post-waking ($B = .88$, $SE = .32$, $p = .01$). Consistent with the findings reported above, for parents of children with lower levels of effortful control, parental hostility was negatively associated with parents' cortisol levels at 45 min post-waking ($B = -1.86$, $SE = .49$, $p < .001$), whereas for parents of children with higher levels of effortful control, parental hostility was not significantly associated with parent cortisol at 45 min post-waking ($B = -.10$, $SE = .45$, $p = .83$). The regions of significance

[1] Given the majority of our sample were mothers ($N = 38$), we reran analyses including gender as a covariate and results were the same (parental hostility x child effortful control, $B = 3.49$, $SE = .88$, $p < .001$). Additionally, when we limited the model to mothers only, results were the same (parental hostility x child effortful control, $B = 3.72$, $SE = 1.01$, $p < .001$).

Table 2. Generalized Estimating Equations: Main Effects of Parenting Behavior and Child Effortful Control on Parent Salivary Cortisol

	Parental Hostility					Child Effortful Control				
	Wald X^2	Pseudo- R^2	*B*	*SE*	*p*	Wald X^2	Pseudo- R^2	*B*	*SE*	*p*
Cortisol Dependent Variable										
Waking	1.81	41.0%	−.60	.45	.18	2.32	5.1%	.19	.39	.63
30 min post-waking	7.88	62.3%	−1.13	.40	.01	.58	9.7%	−.40	.52	.45
45 min post-waking	10.77	59.9%	−1.07	.33	<.01	.66	8.8%	−.34	.42	.42
AUC_g	7.09	47.5%	−5.19	1.95	.01	.51	6.6%	−1.48	2.07	.48
AUC_i	2.08	25.9%	−2.43	1.56	.15	1.76	22.6%	−1.60	1.20	.19

AUC_g = area under the curve with respect to ground; AUC_i = area under the curve with respect to increase.

test indicated that the association between parental hostility and parents' cortisol at 45 min post-waking is significant at levels of child effortful control less than 0.09 (standardized z-score).

There were no other significant interactions between parental hostility and child effortful control on cortisol levels at waking or 30 min post-waking.

Alternative Model

As an alternative model and consistent with Kiel and Buss' (2013) findings, we examined whether parents' CAR moderated the association between child effortful control and parental hostility. We observed one significant interaction between child effortful control and parents' AUC_i on observed parental hostility ($B = .56$, $SE = .26$, $p = .03$). However, tests of simple slopes did not demonstrate significant differences between parents with high ($B = .55$, $SE = .34$, $p = .11$) and low ($B = -.56$, $SE = .35$, $p = .11$) AUC_i on the association between child effortful control and observed parental hostility.

Medication-Free Sample

We tested whether findings were similar when we restricted the sample to parents who were medication-free at the time of the cortisol assessment ($n = 99$). All results described above were similar and remained significant in the medication-free sample with the exception that in the medication-free sample, the main effect of parental hostility on parent AUC_i ($B = -4.55$, $SE = 1.53$, $p < .01$) became significant. Complete results are available upon request to the corresponding author.

Parental Lifetime Depression and Parent Cortisol

Parental lifetime depression was not significantly associated with parents' cortisol levels. Furthermore, results presented above remained significant when parental lifetime depression was included as a covariate in all models and when parents with current depression ($n = 12$) were excluded from analyses.

DISCUSSION

This study examined the main and interaction effects between parenting and child temperament on parents' stress physiology. We found that observed parental hostility was associated with parents' lower cortisol levels at 30 and 45 min post-waking and lower CAR, as indicated by a lower total volume of cortisol secreted

Table 3. Generalized Estimating Equations Model: The Interactive Effects Between Parenting Behavior and Child Effortful Control on Parent AUC_i

	Parent AUC_i				
Variable	Wald X^2	Pseudo- R^2	*B*	*SE*	*p*
Day	.01	.03%	−.17	1.82	.93
Time of waking	7.27	27.1%	−.06	.02	.01
Parent education	.15	.5%	1.00	2.62	.70
Parental hostility	5.41	20.2%	−3.10	1.33	.02
Child effortful control	1.79	6.7%	−1.50	1.12	.18
Child effortful control X parental hostility	12.16	45.0%	3.49	1.00	<.001

AUC_i = area under the curve with respect to increase; parent education 0 = less than 4 year college degree, 1 = 4 year college degree or more.

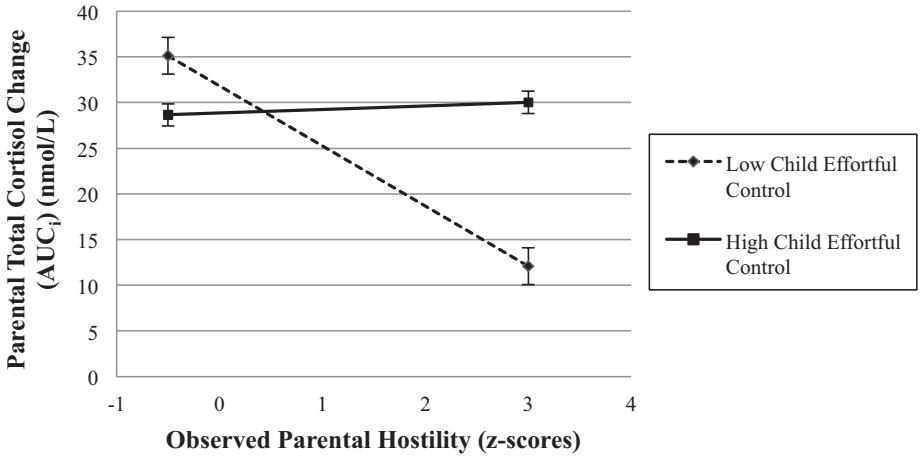

FIGURE 2 Parents' total change in cortisol as a function of high (One standard deviation above the mean) and low (One standard deviation below the mean) child effortful control and standardized parental hostility z-scores. Cortisol change was calculated as area under the curve with respect to increase (AUC_i).

across waking (AUC_g). Moreover, child effortful control moderated the association between parental hostility and the total increase in parents' cortisol across waking or AUC_i. To our knowledge, this is the first study to examine associations between parenting, child temperament, and parents' CAR. Our results suggest that the interplay between parenting and child temperament may be specifically related to parents' HPA axis functioning.

Parental hostility demonstrated a significant main effect on parents' cortisol across the morning. Parents who demonstrated high levels of hostility toward their child during a parent–child interaction task displayed a lower CAR as demonstrated by lower cortisol levels at 30 and 45 min post-waking, and lower AUC_g. Parental hostility was also associated with lower AUC_i in the medication-free parents. Previous literature has demonstrated associations between parenting and maternal cortisol reactivity (Sturge-Apple et al., 2009; Thompson & Trevathan, 2008); however, to our knowledge, no study has examined the effects of parenting on parents' CAR. The CAR is a critical aspect of the HPA axis related to psychosocial factors and physical health, and may reflect a physiological response in anticipation of the day's demands (Fries et al., 2009). Lower CAR, in particular, has been related to a number of negative outcomes, including chronic fatigue, burnout, exhaustion, and depression (Chida & Steptoe, 2009; Fries et al., 2009; Huber, Issa, Schik, & Wolf, 2006). The significance of lower CAR as it relates to individuals' stress exposure and health highlights the critical role of parenting on parents' stress physiology.

Next, we found that child effortful control moderated the association between parental hostility and parent CAR. For parents of children with lower levels of effortful control, higher levels of parental hostility were associated with lower CAR (as indicated by a lower rise in cortisol post-waking or AUC_i) and lower cortisol at 45 min post-waking, whereas lower levels of parental hostility were associated with higher CAR. There were no significant associations between parental hostility and parent CAR and cortisol at 45 min post-waking for parents of children with high levels of effortful control. Our findings are consistent with Martorell and Bugental (2006)'s study demonstrating that associations between parenting and parents' cortisol reactivity vary with respect to child temperament, and our findings provide the first evidence of the moderating role of child effortful control on associations between observed parenting and parents' CAR. Child effortful control is a particularly important construct as it plays a central role in a number of child emotional and behavioral problems; thus, these findings cut across a number of early childhood problems and psychiatric diagnoses and show how children's deficits in self-regulation can get "under a parent's skin." These findings are consistent with theories of parenting stress that highlight the bidirectional and transactional processes involved in associations among parenting, child behavior, and parents' stress physiology (Deater-Deckard, 2004).

Given evidence that the CAR is sensitive to everyday stressors (Chida & Steptoe, 2009), the CAR may capture one aspect of the chronic daily stress from challenging parenting contexts. Previous work has demonstrated parents of children with disabilities, who experience greater daily stress from parenting, had lower cortisol levels throughout the day (Bella et al.,

2011). Furthermore, studies have shown that parents of children with difficult temperaments or behaviors experience greater stress (Coplan, Bowker, & Cooper, 2003). Thus, our findings suggest that parenting a child with low effortful control may be more challenging for more hostile parents, which may contribute to greater strain on the body's stress system. The observed lower CAR may reflect an aspect of allostatic load, or the general wear and tear on the body resulting from chronic stress exposure (McEwen, 1998). Consistent with our findings, one possible result of allostatic load is blunted cortisol responses or hypocortisolism, which may reflect depletion of cortisol from the adrenal gland due to repeated stress exposure (McEwen, 1998). Conversely, we observed that parents who displayed lower levels of hostility with children with lower levels of effortful control displayed a higher CAR, which may be indicative of more adaptive regulatory capacities for managing difficult child behaviors.

Our interactive effect appears to be specific to the rise in cortisol after waking as we observed specific associations with parents' AUC_i and cortisol at 45 min post-waking, but not for parents' AUC_g or other morning samples. Our findings suggest that the post-waking rise in cortisol is blunted rather than the initial waking cortisol levels or the total cortisol secretion across the waking period. In comparison to the AUC_g, the AUC_i captures the sensitivity of change in cortisol levels over time after waking and may demonstrate a unique link to perceived stress (Pruessner et al., 2003). Identifying specific aspects of the CAR that show abnormalities will help identify those at greatest risk and inform treatment development of ways to normalize the parent's stress system.

Given we cannot assume directionality or causality due to the cross-sectional nature of this study, we also examined the moderating role of parents' CAR on associations between child effortful control and observed parental hostility as an alternative model. We found one significant interaction between parents AUC_i and child effortful control on parents' hostility. However, in contrast to findings by Kiel and Buss (2013); the tests of simple slopes for parents with high and low AUC_i were not significant. Thus, these findings give further support to this study's main model in which child effortful control moderates the association between parental hostility and parents' stress physiology.

This study had several strengths. This is the first study, to our knowledge, to examine the main and moderating effects of parenting and child temperament on parents' CAR in a large sample of racially and ethnically diverse parents of young children. This study also had a number of methodological strengths, including a rigorous assessment of the CAR that included the collection of multiple samples of morning cortisol in the first hour of waking across two days, attention to sampling compliance, an observational measure of parenting, and replication of findings in medication-free parents.

This study also had limitations. First, due to the cross-sectional nature of this study, we are unable to test the causality or directionality of our findings. Future longitudinal studies will be a critical next step to delineate the bidirectional and transactional developmental processes through which parenting and parents' stress physiology may influence parent and child health outcomes. Second, we relied on parent reports of child effortful control. Parent reports provide the benefit of assessing child behavior across different contexts and time and allow for an assessment of multiple aspects of child effortful control; nevertheless, parent reports are also more vulnerable to informant biases (De Los Reyes, Henry, Tolan, & Wakschlag, 2003). Future research should incorporate objective, observational measures of child behavior, along with multiple informant reports. Third, the majority of parents in our sample were mothers (92.6%). Gender differences have been observed on the CAR (e.g., Wüst et al., 2000b), as well as parenting behaviors (Gable, Belsky, & Crnic, 1992); thus, it will be important for future research to use novel methods to recruit a larger number of fathers to examine if these models are consistent across mothers and fathers. Fourth, while research has shown that pregnancy and smoking status influence cortisol levels, these factors were not assessed in the current study (e.g., de Weerth & Buitelaar, 2005; Fries et al., 2009).

Fifth, we observed some restricted variability in the measure of observed parental hostility. Thus, future work could benefit from a more sensitive measure of observed parental hostility in non-clinical samples. Sixth, we did not have sufficient power to examine medication use as an additional moderator. While medication use was not significantly associated with parents' cortisol, future work should examine more closely the effects of medication on parents' stress physiology. Lastly, given a portion of our sample was over-selected based on a lifetime history of depression, we cannot necessarily generalize our findings to community samples or clinical samples. Moreover, parental depression has been associated with more hostile parenting behaviors (Lovejoy et al., 2000), dysregulated HPA axis activity (Fries et al., 2009), and child behavior problems (Downey & Coyne, 1990). Thus, continued exploration of the associations between parental depression, parenting, and child factors on parents' stress physiology is warranted. Nevertheless, when parental depression history was included as a

covariate and when parents with current depression were excluded from analyses, results remained the same.

In closing, our findings highlight the complex interplay between parenting and child temperament on parents' stress physiology. To expand on the current findings, future research is needed to identify the mechanisms and processes that lead to parents' dysregulated stress physiology, including the role of parent behavior and child factors. Identifying these mechanisms holds great promise in informing the development of novel interventions that target the intersection of behavior and biology within one of the most fundamental social relationships across development: the parent-child dyad.

NOTES

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REFERENCES

Adam, E. K., Doane, L. D., Zinbarg, R. E., Mineka, S., Craske, M. G., & Griffith, J. W. (2010). Prospective prediction of major depressive disorder from cortisol awakening responses in adolescence. Psychoneuroendocrinology, 35, 921–931.

Adam, E. K., Vrshek-Schallhorn, S., Kendall, A. D., Mineka, S., Zinbarg, R. E., & Craske, M. G. (2014). Prospective associations between the cortisol awakening response and first onsets of anxiety disorders over a six-year follow-up - 2013 Curt Richter Award Winner. Psychoneuroendocrinology, 44, 47–59.

Aiken L. S., & West S. G. (1991). Multiple regression: Testing and interpreting interactions. Newbury Park, CA: Sage.

Barrett, J., & Fleming, A. S. (2011). Annual research review: All mothers are not created equal: Neural and psychobiological perspectives on mothering and the importance of individual differences. Journal of Child Psychology and Psychiatry, 52, 368–397.

Bella, G. P., Garcia, M. C., & Spadari-Bratfisch, R. C. (2011). Salivary cortisol, stress, and health primary caregivers (mothers) of children with cerebral palsy. Psychoneuroendocrinology, 36, 834–842.

Belsky, J., & de Haan, M. (2011). Annual research review: Parenting and children's brain development: The end of the beginning. Journal of Child Psychology and Psychiatry, 54, 409–428.

Bhagwagar, Z., Hafizi, S., & Cowen, P. J. (2005). Increased salivary cortisol after waking in depression. Psychopharmacology, 182, 54–57.

Broderick, J. E., Arnold, D., Kudielka, B. M, & Kirschbaum, C. (2004). Salivary cortisol sampling compliance: Comparison of patients and healthy volunteers. Psychoneuroendocrinology, 29, 636–650.

Chida, Y., & Steptoe, A. (2009). Cortisol awakening response and psychosocial factors: A systematic review and meta-analysis. Biological Psychology, 80, 265–278.

Clow, A., Thorn, L., Evans, P., & Hucklebridge, F. (2004). The awakening cortisol response: Methodological issues and significance. Stress, 7, 29–37.

Coplan, R. J., Bowker, A., & Cooper, S. M. (2003). Parenting daily hassles, child temperament, and social adjustment in preschool. Early Childhood Research Quarterly, 18, 376–395.

Crnic, K. A., & Greenberg, M. T. (1990). Minor parenting stresses with young children. Child Development, 61, 1628–1637.

Deater-Deckard K. (2004). Parenting stress. United States of America: Yale University Press.

De Los Reyes, A., Henry, D. B., Tolan, P. H., & Wakschlag, L. S. (2003). Linking informant discrepancies to observed variations in young children's disruptive behavior. Journal of Abnormal Child Psychology, 37, 637–652.

de Weerth, C., & Buitelaar, J. K. (2005). Cortisol awakening response in pregnant women. Psychoneuroendocrinology, 30, 902–907.

Dougherty, L. R., Tolep, M. R., Smith, V. C., & Rose, S. (2013). Early exposure to parental depression and parenting: Associations with young offspring's stress physiology and oppositional behavior. Journal of Abnormal Child Psychology, 41, 1299–1310.

Downey, G., & Coyne, J. C. (1990). Children of depressed parents: An integrative review. Psychological Bulletin, 108, 50–76.

Egeland, B., Weinfield, N., Hiester, M., Lawrence, C., Pierce, S., & Chippendale, K. (1995). Teaching tasks administration and scoring manual. University of Minnesota.

Eisenberg, N., Cumberland, A., Spinrad, T. L., Fabes, R. A., Shepard, S. A., Reiser, M., … & Guthrie, I. K. (2001). The relations of regulation and emotionality to children's externalizing and internalizing problem behavior. Child Development, 72, 1112–1134.

Feldman, R., Weller, A., Zagoory-Sharon, O., & Levine, A. (2007). Evidence for a neuroendocrinological foundation of human affiliation: Plasma oxytocin levels across pregnancy and the post-partum period predict mother-infant bonding. Psychological Science, 18, 965–970.

First M. B., Gibbon M., Spitzer R. L., & Williams J. B. W. (1996). Structured clinical interview for DSM-IV Axis I disorders: Non-patient edition (SCID-I, Version 2.0). New York: Biometrics Research, New York State Psychiatric Institute.

Fries, E., Dettenborn, L., & Kirschbaum, C. (2009). The cortisol awakening response (CAR): Facts and future directions. International Journal of Psychophysiology, 72, 67–73.

Fries, E., Hesse, J., Hellhammer, J., & Hellhammer, D. H. (2005). A new view on hypocortisolism. Psychoneuroendocrinology, 30, 1010–1016.

Gable, S., Belsky, J., & Crnic, K. (1992). Marriage, parenting, and child development: Progress and prospects. Journal of Family Psychology, 5, 276–294.

Gonzalez, A., Jenkins, J. M., Steiner, M., & Fleming, A. S. (2012). Maternal early life experiences and parenting: The mediating role of cortisol and executive functioning. Journal of the American Academy of Child and Adolescent Psychiatry, 51, 673–682.

Granger, D. A., Hibel, L. C., Fortunato, C. K., & Kapelewski, C. H. (2009). Medication effects on salivary cortisol: Tactics and strategy to minimize impact in behavioral and developmental science. Psychoneuroendocrinology, 34, 1437–1448.

Gunnar, M. R., & Quevedo, K. (2007). The neurobiology of stress and development. Annual Review of Psychology, 58, 145–173.

Gunnar M. R., & White B. (2001). Salivary cortisol measures in infant and child assessment. In L. T. Singer & P. S. Zeskind (Eds.), Biobehavioral Assessment of the Newborn. (p. 167-189). New York: Guilford Press.

Hayes, A. F., & Matthes, J. (2009). Computational procedures for probing interactions in OLS and logistic regression: SPSS and SAS implementations. Behavioral Research Methods, 41, 924–936.

Heim, C., Ehlert, U., & Hellhammer, D. H. (2000). The potential role of hypocortisolism in the pathophysiology of stress-related bodily disorders. Psychoneuroendocrinology, 25, 1–35.

Hellhammer, J., Fries, E., Schweisthal, O. W., Schlotz, W., Stone, A. A., & Hagemann, D. (2007). Several daily measurements are necessary to reliably assess the cortisol rise after awakening: State-and trait components. Psychoneuroendocrinology, 32, 80–86.

Huber, T. J., Issa, K., Schik, G., & Wolf, O. T. (2006). The cortisol awakening response is blunted in psychotherapy inpatients suffering from depression. Psychoneuroendocrinology, 31, 900–904.

Johnson, P. O., & Fay, L. C. (1950). The Johnson-Neyman technique, its theory and application. Psychometrika, 15, 349–367.

Kiel, E. J., & Buss, K. A. (2013). Toddler inhibited temperament, maternal cortisol reactivity and embarrassment, and intrusive parenting. Journal of Family Psychology, 27, 512–517.

Kochanska, G., Murray, K. T., & Harlan, E. T. (2000). Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. Developmental Psychology, 36, 220–232.

Kunz-Ebrecht, S. R., Kirschbaum, C., Marmot, M., & Steptoe, A. (2004). Differences in cortisol awakening response on work days and weekends in women and men from the Whitehall II cohort. Psychoneuroendocrinology, 29, 516–528.

Kupper, N., de Geus, E. J. C., van den Berg, M., Kirschbaum, C., Boomsma, D. I., & Willemsen, G. (2005). Familial influences on basal salivary cortisol in an adult population. Psychoneuroendocrinology, 30, 857–868.

Liang, K. Y., & Zeger, S. L. (1986). Longitudinal data analysis using generalized linear models. Biometrika, 73, 13–22.

Lorber, M. F., & O'Leary, S. G. (2005). Mediated paths to overreactive discipline: Mothers' experienced emotion, appraisals, and physiological responses. Journal of Consulting and Clinical Psychology, 73, 972–981.

Lovejoy, M. C., Graczyk, P. A., O'Hare, E., & Neuman, G. (2000). Maternal depression and parenting behavior: A meta-analytic review. Clinical Psychology Review, 20, 561–592.

Martorell, G. A., & Bugental, D. B. (2006). Maternal variations in stress reactivity: Implication for harsh parenting practices with very young children. Journal of Family Psychology, 20, 641–647.

McEwen, B. S. (1998). Stress, adaptation, and disease: Allostasis and allostatic load. Annals of the New York Academy of Sciences, 840, 33–44.

Olino, T. M., Klein, D. N., Dyson, M. W., Rose, S. R., & Durbin, C. E. (2010). Temperamental emotionality in preschool-aged children and depressive disorders in parents: Associations in a large community sample. Journal of Abnormal Psychology, 119, 468–478.

Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. Psychoneuroendocrinology, 28, 916–931.

Pruessner, J. C., Wolf, O. T., Hellhammer, D. H., Buske-Kirschbaum, A., von Auer, K., Jobst, S., … & Kirschbaum, C. (1997). Free cortisol levels after awakening: A reliable biological marker for the assessment of adrenocortical activity. Life Sciences, 61, 2539–2549.

Putnam, S. P., & Rothbart, M. K. (2006). Development of short and very short forms of the children's behavior questionnaire. Journal of Personality Assessment, 87, 103–113.

Rilling, J. K. (2013). The neural and hormonal bases of human parental care. Neuropsychologia, 51, 731–747.

Rohde, P., Lewinsohn, P. M., & Seeley, J. R. (1997). Comparability of telephone and face-to-face interviews in assessing axis I and II disorders. American Journal of Psychiatry, 154, 1593–1598.

Rothbart, M. K. (2007). Temperament, development, and personality. Current directions in Psychological Science, 16, 207–212.

Seltzer, M. M., Greenberg, J. S., Hong, J., Smith, L. E., Almeida, D. M., Coe, C., & Stawski, R. S. (2010). Maternal cortisol levels and behavior problems in adolescents and adults with ASD. Journal of Autism and Developmental Disorders, 40, 457–469.

Sethre-Hofstad, L., Stansbury, K., & Rice, M. A. (2002). Attunement of maternal and child adrenocortical response to child challenge. Psychoneuroendocrinology, 27, 731–747.

Shiner, R. L., Buss, K. A., McClowry, S. G., Putnam, S. P., Saudino, K. J., & Zentner, M. (2012). What is temperament now? Assessing progress in temperament research on the twenty-fifth anniversary of Goldsmith et al. (1987). Child Development Perspectives, 6(4), 436–444.

Smith, V. C., & Dougherty, L. R. (2014). Noisy spit: Parental noncompliance with child salivary cortisol sampling. Developmental Psychobiology, 56, 1300–1315.

Sturge-Apple, M. L., Davies, P. T., Cicchetti, D., & Cummings, E. M. (2009). The role of mothers' and fathers' adrenocortical reactivity in spillover between interparental conflict and parenting practices. Journal of Family Psychology, 23(2), 215–225.

Thompson, L. A., & Trevathan, W. R. (2008). Cortisol reactivity, maternal sensitivity, and learning in three-month-old infants. Infant Behavioral Development, 31, 92–106.

Vreeburg, S. A., Hoogendijk, W. J. G., van Pelt, J., DeRijk, R. H., Verhagen, J. C. M., van Dyck, R., … & Penninx, B. W. J. H. (2009). Major depressive disorder and hypothalamic-pituitary-adrenal axis activity. Archives of General Psychiatry, 66, 617–626.

Wüst, S., Federenko, I., Hellhammer, D. H., & Kirschbaum, C. (2000a). Genetic factors, perceived chronic stress, and the free cortisol response to awakening. Psychoneuroendocrinology, 25, 707–720.

Wüst, S., Wolf, J., Hellhammer, D. H., Federenko, I., Schommer, N., & Kirschbaum, C. (2000b). The cortisol awakening response-normal values and confounds. Noise and health, 2, 79.